Is CMMI Ready for Prime Time?

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The impending release of the Capability Maturity Model-Integrated-Systems/Software Engineering [1] (CMMI-SE/SW, hereafter referred to as CMMI) has led to a lot of angst in the industry. Many organizations are asking themselves, and their customers, if they should adopt the CMMI as the framework for their process improvement efforts. Such a decision will have a great impact on their operations now and for a long time to come. CMMI is an improvement to existing models, but is it ready to take their place? This article is intended to help organizations decide whether to adopt CMMI based upon a review of the model and the experience of being part of the first pilot assessment using CMMI.

This article begins by describing the technique used for the pilot assessment, followed by discussion of some problems with the CMMI. These problems are described in terms of the difficulty of basing an organization's process improvement on the CMMI, and the difficulty of using the CMMI during an assessment. It is expected that the harder it is for an assessment team to use the CMMI, the less consistency there will be between assessments. Emphasizing the point that the CMMI is a step forward, some of the improvements made by the new model are discussed. Finally, an argument is made that most organizations should not move immediately to the CMMI.

The reader should note that the pilot assessment was conducted in December 1999, using CMMI SE/SW Version 0.2b. Training in the assessment methodology, the Standard CMMI Assessment Method for Process Improvement (SCAMPI) was provided immediately before the pilot assessment. All comments in this article are based upon those versions of the model and methodology, and do not acknowledge changes made since then.

Pilot Assessment

Two assessment teams participated in the pilot. They were both all-star teams in that there was a large proportion of experienced Lead and Candidate Lead Assessors, as well as representatives from industry and the CMMI Product Development Team (PDT). Observers from the PDT were at all team functions in order to learn as much as possible about how the model and methodology would be applied, but were not to intervene in the assessment process.

The two assessment teams reviewed all data independently and drafted separate findings. Both teams attended the same training on the new CMMI model and the new method of assessment, SCAMPI. Each team reviewed the organization's documentation, drafted questions for the interviews, and analyzed data. One team was designated as the A team; it questioned the interviewees and requested further documentation. The A-prime team could not ask questions, but attended all interviews and received copies of all documentation. The teams each drafted findings based on what they had seen and heard.

The findings from the two assessment teams were virtually identical. There was only one minor area of disagreement, and both teams stated that they discussed the area in depth, and could have decided either way. This verifies that the two assessment teams provided the same data would likely interpret the results in a similar fashion.

Process Improvement

The Capability Maturity Model for Software Version 1.1 [2] (CMM) was often criticized for being designed to operate in large organizations doing multimillion dollar projects. Small companies had to be convinced that it could be tailored and applied on small projects as well. The CMMI will surely receive even more criticism in this area, because many of its practices are based upon the experience of the Department of Defense and its contractors. The following process areas (PAs) all seem to have their roots in the large bidder/source selection environment: Supplier Agreement Management, Technical Solution, Verification, Validation, Product Integration, Data Management, Risk Management, and Decision Analysis and Resolution. It will be a real challenge to entice small, high-tech companies to adopt these kinds of practices into their daily business. Many will reject CMMI because it seems to insist upon a large bureaucracy to manage these activities.

Another significant issue is the sheer number of Process Areas and practices. There are 437 practices in the CMMI. An organization that is beginning to implement a process improvement program needs to focus on a small number of areas that will provide quick and measurable payback. CMM Version 1.1 was criticized for being too large; the CMMI is even larger. Having eight process areas at Level 2 and 11 at Level 3 causes a fledgling organization to be daunted by the apparent magnitude of the effort required.

Process improvement according to the CMM for Software Version 1.1 has earned a lot of buy-in from the industry. A major reason for the successful adoption of the CMM is that it is a framework for process, not a description of process. The practices intentionally describe *what* to do, not *how* to do it. The CMMI seems to take a step backward in that regard, and may not be as readily adopted as the CMM.

An example of the more prescriptive nature of CMMI is the Risk Management PA. In Risk Management, the first activity calls for identifying sources and categories of risk. The second has the organization define the parameters for categorization and for controlling the risk management efforts. The fourth requires assessing each risk for likelihood and consequence, and the fifth that every risk has a mitigation plan. These are all good things to do, but describe one particular method of handling risks. They are not necessary for all organizations, applications, or projects. Mitigation plans are normally developed only for high-impact risks; those that are either very likely or could be

catastrophic. This PA is clearly an example of a prescriptive model rather than a framework or guidance, and it will probably adversely impact the industry's willingness to adopt the CMMI. Organizations support the principle of risk management, but a model designed to facilitate process improvement should not prescribe one method over another. During the first pilot assessment, it was difficult for the interviewer to ask the interviewees appropriate, nonleading questions that would elicit answers about the particulars of how risks were managed. Again, this may be a very difficult task for assessment teams and could lead to inconsistent results.

Merged vs. Integrated

CMMI is less an integrated model than a merged one. There is much overlap between some Process Areas that serve to prolong the separation between the systems engineering and software engineering disciplines. It appears to an outsider as if the systems engineering part of the PDT developed their portions of the model, and the software engineers developed theirs, with insufficient cross-talk between the two groups. The different parts were then combined without enough concern for overlap. This "merged vs. integrated" appearance is strengthened by the tone of the activities; the Software PAs are written similarly to CMM 1.1, while the Systems PAs read more like Interim Standard 731. Much more work needs to be done to truly integrate the model.

Assessments using the CMMI

The CMM-Based Appraisals for Internal Process Improvement (CBA IPI) method of assessment allowed for an organization to rule a KPA as nonapplicable, without adversely impacting its maturity level. This was normally done only for Software Subcontract Management, since many development organizations do not contract out any work. The SCAMPI methodology did not allow for nonapplicable PAs during the pilot assessment. The organization made it clear that they did not subcontract any work, and so the assessment team did not rate the Supplier Agreement Management PA, ruling it out of scope. It is also likely that organizations will desire to place other PAs out of scope. Likely candidates are Data Management (not all organizations need a formal process and department to do this), Decision Analysis and Resolution, and possibly Technical Solution and Product Integration. The full scope of these last two may apply only in large organizations and projects. It is expected that this situation will occur on many assessments, and the SCAMPI methodology should clearly spell out what is to be done.

There are many practices in CMMI that are difficult for an assessment team to evaluate. This is especially true in the Systems Engineering Process Areas. Technical Solution has several of these practices. An example is Activity 4,[3] Develop design alternatives and selection criteria that consider the following:

- Life Cycle Cost.
- Technical Performance.
- Complexity.
- Robustness to product operations and the environment.
- Product expansion and growth.

- Cost drivers.
- Technology limitations.
- Sensitivity to construction methods and materials.
- Risk.
- Evolution of equipment drivers and technology.

Since the bulleted items are part of the activity, the organization must have implemented all of them. The laundry list of items in the Activity are all worthwhile tasks, but an assessment team must evaluate each of them and decide if the organization performs them as part of normal practice. There are only two ways to do this: Ask directly about them or ask about the technical solution process as a whole and hope they are all covered during the interviews. Our team tried both methods, and found that neither method works. If the interviewer asks the laundry list of items, the interviewee is overwhelmed by the sheer number of things and cannot possibly remember to answer them all, especially in the stressful environment of an assessment. There is not sufficient time to cover all the information required. If the respondents are not asked about the complete laundry list, they will certainly not cover all of the items and the organization will not receive credit for its practices. It is highly unlikely that a separate interview will corroborate the answers. These types of laundry lists should be covered the same way as in CMM 1.1; that is, as sub-bullets to the Activity. In that way, it is up to the assessment team to keep the laundry list in mind during the process, and focus on the issues that are deemed most important to the organization.

Decision Analysis and Resolution

Decision Analysis and Resolution (DAR) [4] is normally interpreted as a requirement for an organization to have a process to trigger a formal decision-making mechanism when a decision needs to be made on an issue of major concern to an organization's business. The PA goes on to describe some characteristics of both the triggering mechanism and the actual decision-making process.

It is very difficult for an assessment team to reach consensus on the activities in DAR. Our assessment team found that the interviewees had little knowledge of how these types of decisions were made, usually replying that they were not involved or it was not part of their jobs. The people who are involved in making the big decisions covered by DAR are rarely interviewed in an assessment.

The CEO or business unit executive would likely be a major player in such decisions, at least in small- or medium-sized organizations, and is typically the recipient of the assessment findings. That person is normally excluded from the data-gathering interview sessions and the Draft Findings feedback session. In order to build momentum for organizational change, the results of the assessment are presented first to the interviewees to gain their feedback and buy-in. Then, the Final Findings presentation is given to the senior manager in front of the entire organization. The SCAMPI method does not describe a method for interviewing the DAR-level decision makers and having them see the results for the first time as part of the final findings.

The goals described in DAR conflict with the true business

drivers in small and high-tech companies. The motivation for making decisions is often based upon the greater value of time-to-market needs rather than achieving the highest possible quality or productivity. Many of the small or high-tech companies have to be quick, nimble, and flexible, and cannot afford to follow a choreographed decision-making process that is triggered just when the decision is needed. Such a process inevitably delays the decision. Although it may be argued that such a process will usually generate a better solution, these companies' competitiveness is based upon rapid response to conditions. The accuracy of the decision is much less important than the speed.

Finally, the organization's decision makers will not be amenable to having the assessment team question them on their decision-making process. Many leaders of high-tech companies are likely to throw you out of their office if you ask them to describe how they make decisions! This puts the Lead Assessor and the assessment team members in an uncomfortable position. DAR, in its current format, will likely be handled differently on each assessment, and it will be difficult to get consistency.

As a final point on DAR, the new SCAMPI method does not allow this Process Area to be non-applicable during an assessment. It is likely that many organizations will rule DAR out of scope from both their process improvement program and their process assessments. This could result in DAR being an abandoned child of the CMMI, with very little consistent industry data or experience to validate its utility.

Institutionalization Common Features

Another major change to the structure of the model is that all of the institutionalization practices are grouped under an institutionalization goal. Each Process Area has a goal for institutionalization; the practices must be institutionalized as a managed process at Level 2, and as a defined process at higher levels. The change was probably intended to resolve a consistency problem with the CMM-Based Appraisal for Internal Process Improvement [5] (CBA IPI) method. In a CBA IPI, the assessment team needed to come to consensus that the organization demonstrated capability in at least one activity for each of the common features of every Key Process Area (KPA) [6]. Different assessment teams may get sufficient data on different practices but still find that the organization satisfies the KPA, or an assessment team may decide that a weakness on a particular activity prevents the organization from achieving that KPA. This method, however, did allow the assessment team to consider the organization's business needs in that decision.

In the SCAMPI, all of the institutionalization practices map to the last goal in each PA, and an organization must demonstrate capability in all of those practices to achieve that goal (and the PA). There are 10 institutionalization practices in each PA, resulting in 240 institutionalization practices the team must investigate and come to consensus on in a Level 5 assessment. Each of these practices must be performed as a defined process.

A defined process is a managed process that is tailored from the organization's set of standard processes. Deviations from the managed process are documented, justified, reviewed, and approved. A defined process also has clearly stated inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria. A managed process is defined as being planned, documented, performed, monitored, and controlled at the local level.

There are 18 separate characteristics for a defined process mentioned in the above definitions. Therefore, there are 4,320 characteristics of process that an assessment team must verify just for the institutionalization practices! This is clearly an onerous requirement that an assessment team has insufficient time to accomplish, and will likely lead to less, not more, consistency between assessments.

The goal of investigating institutionalization is to ensure that the practices demonstrated for the assessment team are truly being used throughout the organization as a part of normal activities. In other words, they were not put into practice just for the assessment, either functionally (on the few projects being investigated) or temporarily (only shortly before the assessment). The assessment team must be confident that the practices will continue into the future after the assessment. This confidence can be achieved by listening closely for those instances where the organization demonstrates a lack of institutionalization, and following up with further questioning. A consistent pattern of successful implementation and continuous improvement of processes across the organization should be sufficient to enable the team to be confident that processes will continue into the future.

During our pilot assessment, it quickly became evident that the team could not verify all of the institutionalization practices across the organization. For example, practitioners must be trained in each of the managed and defined processes. Our team began investigating the training by asking people if they had been trained in each of the PAs as we discussed them. First, the repetition seemed to the team, and likely to the interviewees, that we were trying to trick them or catch them in a falsehood. Second, the repeated questioning on whether they have received training in all areas took an inordinate amount of time, especially compared to the value of the responses. Third, as discussed above, a laundry list approach is insufficient to get at all of the required training unless it becomes too leading to serve as corroboration. Fourth, verifying the training by reviewing records is inefficient and often fruitless. We wound up doing what most assessment teams do in CBA IPIs—sampling and investigating where we thought we had found inconsistencies. This approach should be standardized into the SCAMPI by describing it.

Improvements

Despite the problems described above, many improvements have been made. Requirements Management is now broken into two PAs, one at Level 2 and another at Level 3. It has also been explicitly described as being a management function throughout the development life cycle, rather than only being performed at the beginning of the project. The CMMI now defines eight different types of requirements, further emphasizing their importance to good project management across the life cycle.

In Project Planning, estimates must now be based upon the previous step (i.e., " . . .effort and cost . . . is determined by using historical data or models . . . from work product and task attributes"). Implementing Risk Management as a separate PA is

a great idea, and shows that the PDT was listening to industry concerns.

The CMM's awkward mapping of Key Practices to goals has been improved by having each practice map to a single goal (an exclusive many-to-one mapping for database designers). The mapping was evidently spelled out as one of the PDT's requirements, because it apparently has been applied without exception. Although this makes the assessment rating exercise much simpler, it imposes strict rules on the structure of the model that in some cases lead to a seemingly contrived or limited mapping of activities to goals.

Setting up Measurement and Analysis (M&A) as a separate PA is also an improvement. Each KPA in CMM 1.1 had an M&A Common Feature. Lower maturity organizations had difficulty understanding that the measurements were supposed to integrate across the entire process, allowing for coordinated management. The CMMI's separate PA for this should help to implement a more comprehensive metrics program. An argument could be made that Level 1 organizations cannot define proper metrics or design a system to collect and analyze them, so M&A might be a better fit at Level 3, but this is still a better approach.

Bringing systems engineering practices into the model should be a major advantage. Many software-only organizations were insistent that they did not do systems engineering, but all software must run on some computer system, and interface with others. Taking advantage of the rich history and experience of systems engineers can only help the software industry, and systems people can certainly benefit from the software experience, especially with process improvement.

Summary

The CMMI incorporates some major improvements over CMM 1.1. However, it also has some problems that need to be resolved. Organizations that have a mandate from customers to adopt CMMI should certainly do so, but if the goal is to achieve the benefit of process improvement, it may be better to wait for further model improvements. Major suppliers to DoD should be encouraged to implement as much as possible of the CMMI in the near future, but smaller companies will probably benefit most by waiting until many of these problems are fixed.

In short, the CMMI is ready for release to a selected audience but probably not yet ready for prime time.✍

References

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About the Author

Bill Pierce has been involved in software process improvement for more than 15 years. He is authorized to lead CBA IPIs and to teach Introduction to the CMM. He has a master's degrees in business administration and engineering physics. He was a founding member of the SEPG in 1991 at Hill Air Force Base in Ogden, Utah. The SEPG started and managed an organizational process improvement program, attaining Level 3 in 1995 and Level 5 in 1998. The division was the first government organization and the sixth organization of any kind to achieve Level 5. Pierce was a leader in the process improvement efforts and managed one of the focus projects chosen for the assessment. In October 1999, Pierce founded Northern Utah Process Improvement Technologies. The company specializes in analyzing an organization's business needs and situation, designing and facilitating a reasonable and affordable process improvement program.

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